XVII. *On the Constitution of the Resins. Part II.* *By* JAMES F. W. JOHNSTON, *Esq. M.A., F.R.S., Professor of Chemistry and Mineralogy in the University of Durham.*

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III. *The Resin of Gamboge, or Gummi Gutt.*

THE medical and commercial values of the several varieties of gamboge which occur as articles of commerce in the European markets, and their botanical origin, have lately been investigated by Dr. CHRISTISON*. He found the different varieties to contain respectively

	Siam.		Ceylon.	
	Pipe.	Cake.	1.	2.
Resin	72·2	64·8	70·2	75·5
Cerabin	23·0	20·2	19·6	18·3
Cerasin	......	......	......	0·7
Fecula	......	5·6	......	......
Woody fibre, &c.	......	5·3	5·6	......
Moisture......	4·8	4·1	4·6	4·8
	100	100	100	99·3

The resin of gamboge is soluble in alcohol, and largely in ether; and so far as experiments go may be obtained by either solvent free from the foreign substances with which it is mixed in the resin of commerce. Like many of the other resins, acid as well as basic, it retains with considerable obstinacy the last traces of these solvents, and requires the prolonged action of a temperature above that of complete fusion fully to expel them.

1. 5·32 grains of the resin precipitated by water from its solution in alcohol, dried and fused at 212° FAHR., gave $\ddot{C} = 13·98$, and $\dot{H} = 3·52$ grains.

2. 6·685 grains of the same gave $\ddot{C} = 17·64$, and $\dot{H} = 4·43$ grains.

3. 7·675 grains of the resin obtained by evaporating the ethereal solution and prolonged heating, gave $\ddot{C} = 20·060$, and $\dot{H} = 5·04$ grains.

4. 8·235 grains of the same heated to 350° FAHR., gave $\ddot{C} = 21·640$, and $\dot{H} = 5·365$ grains.

5. To be certain that alcohol and ether were absent, the resin was dissolved in caustic potash, precipitated by muriatic acid, washed, dried, and fused at 350° FAHR. In this state it fused less readily, and was of a darker colour.

13·146 grains gave $\ddot{C} = 34·432$, and $\dot{H} = 8·67$ grains.

* Proceedings of the Royal Society of Edinburgh, March 7, 1836.

These results give per cent. respectively,

	From alcohol.		From ether.		After solution in potash and fusion at 350°.
	Fused at 212°.	Fused at 212°.	Fused at 212°.	Fused at 350°.	
Carbon ..	72·662	72·763	72·280	72·668	72·406
Hydrogen	7·352	7·363	7·296	7·225	7·243
Oxygen ..	19·986	19·874	20·424	20·351	20·351
	100	100	100	100	100

It is difficult to arrive at a satisfactory conclusion in regard to the true formula for this acid resin.

The results of analysis approach exceedingly near to the beautifully simple formula $C_5\ H_3\ O$, or $C_{40}\ H_{24}\ O_8$, which gives

		Calculated.	Experiment.
C_5 =	382·185 =	73·550	72·763
H_3 =	37·438 =	7·205	7·363
O_1 =	100·000 =	19·245	19·874
	519·623	100	100

This formula is further interesting, because of the close relation it would establish between oil of turpentine and its resin, and that of gamboge; since

Oil of turpentine.

$$C_5\ H_4 \begin{cases} -\ H \\ +\ O \end{cases} = C_5\ H_3\ O.$$

The fact, however, that in all the analyses there is a constant deficiency of carbon to the amount of nearly one per cent., renders the formula suspicious. It is true that the gambodic acid has a strong affinity or attraction for ether and alcohol, and that a certain quantity of these substances may have been present in some of the specimens analysed; yet it would be necessary to suppose a much larger admixture of them than seems possible, in order to account for so great a diminution in the per centage of carbon. Neither can we admit the presence of these substances in the resin after solution in potash, though the carbon in this also is considerably less than the formula requires.

In order to determine whether a still higher temperature than 350° Fahr. would drive off a further portion of alcohol from the resin precipitated from its solution by water, I heated it to 400° + Fahr., when it ceased to emit its agreeable fragrant odour, gave off white vapours, and became slightly darker in colour. In this state 11·38 grains gave $\ddot{C}$ = 30·23, $\dot{H}$ = 6·73 grains, or per cent.,

Carbon	=	73·791
Hydrogen	=	6·601
Oxygen	=	21·608
		100

The carbon here is sufficiently great, but there is much too little hydrogen for the formula ($C_5\ H_3\ O$), to which this resin seems so closely to approximate.

After fusion at this temperature, however, the gambodic acid was no longer wholly soluble in alcohol, nearly one half of its bulk being left behind in the form of a yellow powder when digested in this liquid. This powder was collected, washed with alcohol, and heated for a long time at 212° + FAHR. previous to analysis. At 400° FAHR. it undergoes no apparent change; at 500° FAHR. it becomes brown, and gradually darkens, but does not melt. 7·30 grains gave $\ddot{C}$ = 18·93, and $\dot{H}$ = 4·62, or per cent.,

	Experiment.	Calculated.
Carbon	= 71·703	72·033
Hydrogen	= 7·031	6·762
Oxygen	= 21·266	21·205
	100	100

This result agrees with the formula $C_{40}\ H_{22}\ O_9$, according to which the second column is calculated.

The formula which most nearly represents the result of experiments on the unchanged resin is $C_{48}\ H_{29}\ O_{10}$. This gives

		per cent.
C_{48} =	3668·976 =	72·929
H_{29} =	361·908 =	7·193
O_{10} =	1000·000 =	19·878
	5030·884	100·000

in which there is an allowance for loss of carbon and for a similar slight excess of hydrogen in the results of analysis, being the directions in which errors are likely to occur.

It is satisfactorily ascertained, however, that the gamboge of commerce, as we have found reason to conclude is the case with dragon's blood, undergoes a process of manufacture before it is brought to market. Like the reed dragon's blood, it has all the appearance of having been fused and moulded into shapes; the effect of such fusion in the case of the red resin is, as we have seen*, to diminish the amount of carbon about one per cent., and if we suppose a similar change produced on the gamboge, the deficiency of carbon in the analysis will be sufficiently accounted for. The likelihood of an analogous change in the two resins is the greater, as they belong apparently to a kindred group, the several members of which are related almost as closely as mastic and colophony. On comparing the quantity of hydrogen found by analysis with that given by the formula $C_{40}\ H_{24}\ O_8$, 7·205 per cent., we find them approach so closely as scarcely to allow for the necessary errors of experiment, but in the reed dragon's blood there was a similar deficiency, so that until we have the opportunity of analysing the gamboge resin as it issues from the tree, we might adopt the formula to which the results appear to point. There is an analogy, however, in favour of the formula

* See page 134 of the present volume.

$C_{40} H_{23} O_8$ containing one equivalent less of hydrogen, which is not unworthy of attention. When heated above 400° FAHR. we have seen that this resin is partly changed into a nearly insoluble resin $= C_{40} H_{22} O_9$, that is

$$C_{40} H_{23} O_8 \left\{ \begin{matrix} -H \\ +O \end{matrix} \right. .$$

In like manner mastic resin when so heated is in part changed into $C_{40} H_{30} O_5$, that is

$$C_{40} H_{31} O_4 \left\{ \begin{matrix} -H \\ +O \end{matrix} \right. .$$

It is reasonable to suppose that the nature of the change which takes place is the same in both; and though I do not consider, notwithstanding the precautions adopted, that the number of atoms of hydrogen in any of the formulæ I have given for the resins can be considered *absolutely certain*, yet there being a reasonable probability that mastic resin A, is represented by $C_{40} H_{31} O_4$, there is reason from the present analogy to infer that gamboge resin is $C_{40} H_{23} O_8$.

One interesting and important fact may be considered as established, whichever of these formulæ be adopted, that a small change in the number of atoms of hydrogen only, may give birth to new resins possessed of very different properties. We have for example,

Colophony $= C_{40} H_{30} O_4$ Liebig.
Mastic A. $= C_{40} H_{31} O_4$

represented generally by

$$C_{40} H_{32-x} O_4$$

the resin of which

$C_{40} H_{32} O_4$ is the formula, being undetermined.

And we have also

Resin of dragon's blood $= C_{40} H_{21} O_8$
Resin of gamboge. . . . $= C_{40} H_{23} O_8$?

And the general formula

$$C_{40} H_{24-x} O_8$$

may represent a second large group, of which, as in the former, only two members are as yet determined.

In the present stage of our inquiry it would be premature to dwell on theoretical indications as to what we may hereafter expect to meet with, but it may be remarked that H_{32} and H_{24} seem to point to a series, of which H_{64}, H_{16} and H_8 are members, and which may respectively form the starting-points as it were, of new groups.

Salts of Gambodic Acid.

Gambodiates of Potash and Soda.—The salts of the alkaline metals may be formed by dissolving or digesting the acid in solutions of the caustic alkalies. In strong solutions the salt is very sparingly soluble, so that by digesting the acid in such solution, the compounds may easily be obtained in a solid state. In colour they are some-

what darker than the pure resin, and very soluble in pure water, giving reddish-brown solutions, and though more sparingly, yet still largely soluble in alcohol. They are decomposed by the dilute mineral acids, which precipitate the acid from its saline solutions unchanged, and in the form of a pale-yellow bulky powder.

Gambodiate of Ammonia.—Gambodic acid dissolves slowly in dilute caustic ammonia, giving a brownish-red solution. The solution is most readily obtained by adding caustic ammonia to the alcoholic solution of the acid, diluting largely with water and distilling or boiling off the alcohol and excess of ammonia. Evaporated to dryness at a temperature below 212° FAHR., it leaves a brittle resinous mass having the colour of the acid. Instead of the fragrant smell of the resin, however, it has assumed a faint unpleasant animal odour. It is insoluble in pure water, but dissolves on the addition of a little caustic ammonia. It dissolves also in alcohol, and is decomposed by the mineral acids. Boiled in a solution of caustic potash, ammonia is evolved and a salt of potash formed. Its solution in water precipitates the ammonia nitrate of silver and the ammonia acetate of lead (PAYEN's salt) of a yellow colour, and the ammonia sulphate of copper of a dark-reddish-brown.

Earthy and Metallic Salts.—On these salts I have made many experiments with results in some cases sufficiently discordant, and which led me at first to consider that the equivalent of this resin should be represented by ($C_{50}H_{29}O_{10}$), instead of ($C_{40}H_{23}O_8$), as the analysis of the resin appears to indicate. I am now inclined, however, to adopt the formula containing C_{40}, as entering into the expression for the gambodiates, and to attribute the observed differences between experiment and calculation to the difficulty of obtaining these as well as other resinous compounds in a perfectly pure state, especially free from mutual admixture. To this conclusion I am further led by the study of the salts of mastic resin A, of which an account has already been given.

Properties of the Earthy and Metallic Gambodiates.—1. When fresh prepared from alcoholic solutions these salts are yellow, slightly soluble in alcohol, and insoluble in water. When first precipitated from solutions of chloride of calcium and nitrate of strontia, by means of ammonia, they are of a beautiful red, but by standing they subside yellow. Precipitated from ammoniacal *aqueous* solutions, they are brownish or brownish-red.

2. Collected on the filter after precipitation from alcoholic solutions, washed with alcohol, and dried by pressure on bibulous paper, they are in the form of a beautiful yellow powder, in which state they remain, if dried by a very gentle heat in the open air, raised after a sufficient time to 212° FAHR. If immediately on being dried by pressure as much as possible between folds of paper, they are exposed to a heat of upwards of 100° FAHR., they melt, and run into a thin liquid, which on cooling solidifies into a red brittle resin, giving a yellow powder. This property, which is common to these with the salts of many other resins, appears to indicate a combination of the salts with alcohol, from the last portions of which, like the resins themselves, they

are with difficulty separated. They may be heated, however, to 350° or 400° FAHR., without decomposition, emitting only the fragrant odour characteristic of the gambodic acid itself. At or under this temperature they melt, those of the earths excepted, and on cooling assume the appearance of a reddish-brown resin, not unlike the acid, and like it giving a beautiful yellow powder. At a higher temperature they are decomposed, giving off empyreumatic products. The salt of silver is discoloured by exposure to the air, and when dry is of a dirty-dark-green. They are all decomposed by boiling in acetic and dilute nitric acids.

I had spent much time in preparing these salts by means of alcoholic solutions, before I discovered that the resin possesses a property which enables us to prepare very many of its salts from aqueous solutions. The gambodiate of ammonia being soluble in dilute ammonia, and *not* precipitable by water, it is sufficient to add caustic ammonia to an alcoholic solution of the resin, and to dilute with water, when the addition of an ammoniacal solution of magnesia, oxide of manganese, oxide of copper, oxide of zinc, acetate of lead, or of any other oxide soluble in caustic ammonia, causes a precipitate of the corresponding gambodiate of a brownish-red colour. By washing with dilute ammonia these may be obtained in a state of comparative purity*. Analogous compounds may be formed by adding an alcoholic solution of the resin to similar solutions of the metallic salts with or without the addition of ammonia.

A. *Salts of Lead.*—1. When a solution of the resin in alcohol is mixed with one of acetate of lead, a yellow precipitate falls. Washed with alcohol and dried

				per cent.
a. At	212° FAHR.,	11·425 grs. gave 2·224 oxide of lead	=	19·466
b. After fusion, at	370° FAHR.,	13·03 grs. gave 2·58 oxide of lead	=	19·80

A second portion thrown down from a solution in which a large excess of resin was present gave only 17·36 per cent. of oxide. A *sesquisalt* $= 3\ (C_{40}\ H_{23}\ O_8) + 2\ Pb\ O$, contains 18·32 per cent. of oxide, and it will be recollected that mastic resin A. in similar circumstances gave also a sesquisalt†.

2. To the mixed solutions as above, after the precipitate was separated, caustic ammonia was added with agitation. The new precipitate was also yellow, but when washed and dried 14·74 grs. gave only 2·046, or 13·88 per cent. of oxide of lead. This agrees with the formula $Pb\ O + 2\ (C_{40}\ H_{23}\ O_8)$ which contains 14·40 per cent. of oxide, though it is not easy to understand why a *bi*salt should be thrown down when the solution is rendered more neutral by the addition of ammonia.

3. An ammoniacal solution of the resin was diluted with water, and a solution of PAYEN's ammoniacal subacetate of lead was added to it. A yellow precipitate fell which was collected, carefully washed, and dried at 212° FAHR. At a low heat it took fire and burned like tinder, without melting.

* This property renders gamboge of great value for experimental illustration of the properties of the resins in the Class-room.

† Vid. ante, p. 124.

10·733 grs. left 5·284 grs. of oxide of lead = 49·231 per cent. This indicates three of base to one of acid; the formula 3 $PbO + (C_{40} H_{23} O_8)$ requiring 50·23 per cent.; and this tribasic salt is precisely the analogue of the *tribasic* acetate from which it is formed.

After being digested in acetic acid, and again washed and dried, this salt lost five-sixths of its base, becoming a *bi*salt. Thus 11·066 grains left 1·635 of oxide of lead = 14·777 per cent.; the formula, as already stated, requiring 14·40 per cent. That an acid salt should be formed under these circumstances is what we should expect; but whether a *bi*salt is the constant result I have not determined.

B. *Salts of Copper.*—1. A dilute ammoniacal solution of the resin in water was mixed with one of ammoniaco-sulphate of copper; a brownish-yellow precipitate fell, which was washed with dilute ammonia, and dried at 212° Fahr.

11·037 burned in the air left 1·197 $\dot{C}u$ = 10·845 per cent.
13·455 of another portion left 1·40 $\dot{C}u$ = 10·405 per cent.

A portion of the dry salt, after boiling in dilute ammonia, still left 10·994 per cent. of oxide.

These results indicate a neutral salt, the formula $\dot{C}u + (C_{40} H_{23} O_8)$ requiring 10·68 per cent. of oxide of copper*.

2. A further portion of the salt was prepared by adding the ammoniacal resin to a solution of common sulphate of copper; and, as this might contain excess of oxide, one portion of it was digested while moist in *hot* dilute ammonia. When dried it left in two experiments 18·951 and 18·830 of oxide per cent. respectively. Another portion was boiled in strong caustic ammonia, by which, as appeared from the colour of the solution, a portion of the acid was taken up. Washed, dried, and burned, it left 14·666 per cent. of oxide of copper.

The former result agrees with 2 $\dot{C}u + (C_{40} H_{23} O_8)$, which requires 19·31 per cent. of oxide.

The latter agrees with 3 $\dot{C}u$ + 2 $(C_{40} H_{23} O_8)$, which requires 15·21 per cent. of oxide.

It is impossible, however, without several repetitions of these experiments, to say that these coincidences are more than accidental, though from analogy it appears probable that such compounds do exist. Above all, their true nature can only be known by the ultimate analysis of the salts,—a work of great labour, but which I do not despair of being able to undertake. By varying the mode of preparation I obtained a copper salt by direct precipitation, containing 14·824 per cent. of oxide, agreeing with one of those just described. But if the three classes of salts above obtained be constant and definite, the circumstances under which they may be formed without failure requires further study.

C. *Salts of Zinc.*—The gambodiate of zinc is obtained by mixing the ammoniacal

* The equivalent of oxide of copper being 495·695.

resin with a solution of zinc in ammonia, or with an ammoniacal solution of sulphate of zinc. It is of a brownish-yellow colour. If the solution be too largely diluted with water, an excess of oxide of zinc is apt to be thrown down along with the salt. Thus the first portion I prepared gave me 14·17 per cent. of oxide of zinc, while another prepared with more care gave me in two experiments 11·242 and 10·976 per cent. respectively. A neutral salt = $ZnO + (C_{40} H_{23} O_8)$, contains 10·83 per cent. oxide of zinc.

D. *Salts of Lime, Strontia, and Magnesia.*—*a.* To alcoholic solutions of chloride of calcium and of nitrate of strontia, ammonia was added, and afterwards a solution of gambodic acid in alcohol. The former gave an abundant, the latter a very sparing precipitate. The mixed solutions at first became of a beautiful red colour, but the precipitate, as it fell, gradually assumed a more yellow shade. Washed without access of air, and dried at 360°, the lime salt gave in two experiments 6·119 and 6·192 per cent. of lime; the strontia salt gave 9·877 per cent. of strontia.

If these results are to be depended upon, they indicate a *sesqui*salt in both cases; since

$$\dot{C}a + 1\tfrac{1}{2}\,(C_{40} H_{23} O_8) \text{ contains } 5{\cdot}72 \text{ per cent. of lime,}$$

and

$$\dot{S}r + 1\tfrac{1}{2}\,(C_{40} H_{23} O_8) \text{ contains } 9{\cdot}43 \text{ per cent. of strontia.}$$

b. The ammoniacal resin in water gives, with ammoniacal sulphate of magnesia, a copious precipitate, which, dried and burned, yielded 4·542 and 4·681 per cent. of magnesia, which, however, is not reconcileable to any formula.

E. *Salts of Silver.*—1. Newly precipitated oxide of silver, digested in gambodic acid in alcohol, gave a dark-brown salt, which fused at 360° FAHR; and of which, when burned, 20·335 grains left 5·46 of silver = 28·762 per cent. of oxide. A neutral salt, $AgO + (C_{40} H_{23} O_8)$, contains 25·94 per cent., to which the salt above obtained approximates. It will be readily understood that very careful agitation would be required to bring all the particles of the oxide introduced in the state of powder into contact with the resin held in solution, and that an excess of silver is to be expected in a salt prepared by such a process.

2. When an alcoholic solution of the resin is poured into a similar solution of nitrate of silver, no precipitate falls; but if the mixture be allowed to stand for some time, the inside of the glass vessel becomes covered with a coating of metallic silver, and a small quantity of a black powder gradually falls to the bottom. The same effect follows if the resin of dragon's blood be used, and in a still more marked manner with the pure resin of guaiacum. If ammonia be added, a yellow precipitate falls, which is speedily discoloured by the air, and ultimately becomes dark-green. Carefully dried,

6·94 grains left 1·00 grain of silver = 15·475 per cent. of oxide of silver.
7·766 grains left 1·146 grains of silver = 15·848 per cent. of oxide of silver.

These results indicate the formation, as was the case with mastic resin A*, of a *bi*-salt, containing also, like the salt of that resin, a small excess of silver. The formula $Ag\,O + 2\,(C_{40}\,H_{23}\,O_8)$ requires 14·90 per cent. of oxide of silver.

3. Into an aqueous solution of ammonia nitrate of silver, an ammoniacal solution of gambodic acid was slowly poured with agitation, a yellow precipitate began to fall, which re-dissolved on a further addition of the resin, and was again thrown down on adding ammoniacal nitrate of silver. The yellow precipitate gradually collected into brown flocks, and formed a brown coherent sediment, leaving the supernatant liquid of a pale yellow colour. The precipitate was well washed with distilled water, collected on the filter, and dried at 250° FAHR., till at that temperature it ceased to soften.

13·17 grains burned in the air left 1·17 of metallic silver, or 9·54 per cent. of oxide.

7·866 grains left 0·725 of silver = 9·90 per cent. of oxide.

A salt consisting of three equivalents of acid to one of base, or $Ag\,O + 3\,(C_{40}\,H_{23}\,O_8)$, contains 10·22 of oxide of silver. We may safely consider the compound prepared by this method, therefore, as a *ter*salt, the excess of ammonia present probably retaining the silver in solution, so as to prevent its forming a more basic combination. It is not unlikely that by varying the process a *bi*salt might be obtained from aqueous solutions similar to that which was given by alcoholic solutions.

Constitution of the Salts of Gambodic Acid.

Of the salts above described I have subjected to ultimate analysis only the *bi*salt of silver, obtained by mixing the alcoholic solutions of the resin and of nitrate of silver, and adding ammonia. This salt contained 15·88 per cent. of oxide of silver, and when burned with oxide of copper,

$$8·19 \text{ grains gave } \ddot{C} = 18·02, \text{ and } \dot{H} = 4·47.$$
$$7·60 \text{ grains gave } \ddot{C} = 16·875, \text{ and } \dot{H} = 4·11.$$

These results are equal to

	A.	B.	Calculated.
Carbon	= 60·954	= 61·40	61·51
Hydrogen	= 6·065	= 6·00	5·77
Oxygen	= 17·098	= 16·72	17·82
Oxide of silver	= 15·883	= 15·88	14·90
	100	100	100

The numbers in the third column are calculated according to the formula $Ag\,O + 2\,(C_{40}\,H_{23}\,O_8)$, and to these numbers the experimental results approximate very closely. Like the similar analyses of the salts of mastic resin A†, these show that in combining with oxides the gambodic acid does not part with the elements of water. They are opposed, however, to the view suggested by the constitution of some of the salts of

* Ante, p. 126. † Ante, p. 128.

that resin, that the metal replaces an equal number of equivalents of hydrogen when it combines with the resin; and they support rather the other view, which would represent the normal state of the acid resin to be that in which it exists when in a state of combination, and that the hydrogen contained in their salts of the metallic oxides is the true quantity which enters into the composition of these bodies.

Conclusions.—From the preceding investigation it appears,

1. That the most probable formula for gamboge resin is $C_{40}\ H_{23}\ O_8$, though all the specimens analysed yield too little carbon by nearly one per cent. This deficiency is supposed to be due to a change produced during the preparation of the natural resin for the market.

2. When heated to about 400° FAHR. it undergoes partial decomposition, a resin soluble in cold alcohol being formed, and another insoluble in that liquid. The constitution of the latter seems to be represented by $C_{40}\ H_{22}\ O_9$.

3. It forms with the metallic oxides numerous classes of salts, the existence and constitution of which the preceding experiments must be considered as only rendering *probable*. A complete study of the resinous salts, and of the circumstances under which the several classes of them are necessarily formed, though it would involve much labour, would probably lead to interesting results. The various saline compounds obtained as above described may be classed as follows, representing the formula $C_{40}\ H_{23}\ O_8$ by $\overset{r}{G}$.

	Formula.	Oxide per cent. Found.	Oxide per cent. Calculated.	How obtained.
1. *Ter*salts ...	$Ag O + 3 \overset{r}{G}$	9·90	10·22	By mixing ammoniacal aqueous solutions.
2. *Bi*salts ...	$Ag O$	15·47	14·90	Mixing alcoholic solutions and adding ammonia.
	$Pb O$ } $+ 2 \overset{r}{G}$	14·77	14·40	By digesting in dilute acetic acid, the salt precipitated on mixing ammoniacal aqueous solutions.
3. *Sesqui*salts	$2 Pb O$	19·46	18·32	Mixing the resin in alcohol with acetate of lead in alcohol.
	$2 Ca O$ } $+ 3 \overset{r}{G}$	6·119	5·72	Mixing the resin with chloride of calcium in alcohol, and adding ammonia.
	$2 Sr O$	9·87	9·43	Mixing the resin with nitrate of strontia in alcohol, and adding ammonia.
4. *Neutral* ...	$Ag O$	28·76	25·94	Digesting the resin on fresh precipitated oxide of silver.
	$Cu O$ } $+ \overset{r}{G}$	10·84	10·68	From ammoniacal sulphate of copper by resin in dilute ammonia.
	$Zn O$	10·97	10·83	From ammoniacal sulphate of zinc by resin in dilute ammonia.
5. *Subsesqui*	$3 Cu O + 2 \overset{r}{G}$	14·66	15·21	Boiling the fresh precipitated $Cu O + \overset{r}{G}$ in concentrated caustic ammonia.
6. *Di*salts ...	$2 Cu O + \overset{r}{G}$	18·95	19·31	Digesting do. in hot dilute caustic ammonia.
7. *Tri*basic...	$3 Pb O + \overset{r}{G}$	49·23	50·23	Mixing ammonia acetate of lead (tribasic) with the resin in dilute caustic ammonia.

I cannot persuade myself to regard this formidable list of salts without suspicion, especially as several of them have been formed only once. In detailing my results and observations, however, I have in some measure cleared the way for future inquirers.

IV. *Resin of Guaiacum.*

When the resin of guaiacum of the shops is treated with alcohol in the cold it is nearly all dissolved, giving a dark-brown solution. On evaporating this solution in a flat dish, and heating it for twelve hours at a temperature rising from 180° to about 250° FAHR., a very beautiful transparent ruby-coloured resin is obtained, brittle and electric, melting at 212° FAHR., and emitting an agreeable fragrant odour.

Of this resin thus carefully dried,

A. 10·647 grs. gave $\ddot{C} = 27·167$ and $\dot{H} = 6·585$

B. 10·995 grs. gave $\ddot{C} = 27·975$ and $\dot{H} = 6·733$

these results gave per cent.

	A.	B.
Carbon . =	70·555	70·35
Hydrogen =	6·870	6·80
Oxygen . =	22·575	22·85
	100	100

and they correspond most closely with the formula $C_{40}\,H_{23}\,O_{10}$ which gives

40 Carbon . =	305·75 =	70·37
23 Hydrogen =	28·70 =	6·60
10 Oxygen . =	100·00 =	23·02
	434·45	100

This resin in a natural arrangement, therefore, must stand in the same group with the resins of dragon's blood and of gamboge, which as we have already seen may be represented by

Resin of dragon's blood $C_{40}\,H_{21}\,O_{8}$

Resin of gamboge . . . $C_{40}\,H_{23}\,O_{8}$

Resin of guaiacum . . $C_{40}\,H_{23}\,O_{10}$

Salts of Guaiacum Resin.—When the solution of this resin in alcohol is added to an alcoholic solution of acetate of lead in excess, a white precipitate falls, which becomes blue on exposure to the sun's rays*. After separating the precipitate, ammonia throws down a further portion from the supernatant liquid. I have analysed three successive portions of the first of these compounds, which contains two equivalents of oxide of lead to forty of carbon; but the results are so little concordant with the analysis of the uncombined resin as to render further investigation necessary.

With nitrate of silver this resin gives no precipitate, but on standing exposed to the light, the silver, in considerable quantity, is thrown down in the metallic state. I have not examined what change of composition the resin undergoes during this deoxidation of the metal.

* A delicate photogenic paper may be formed by first washing with an alcoholic solution of guaiacum resin, and afterwards with one of neutral acetate of lead.

V. *Acaroid Resin.* (*Botany Bay Resin, Yellow Gum.*)

This resin exudes from the *Xanthorrhœa hastilis,* is of a darker reddish yellow colour than gamboge, comes to this country generally mixed with the spines and bark of the tree, gives in alcohol and ether a much darker solution than gamboge, and a darker resin when evaporated. It emits also a peculiar fragrant odour when melted, and differs further from gamboge in being almost entirely precipitated by water from its solution in alcohol, even when much ammonia has been added. Dried in a thin film at 250° FAHR. for twelve hours,

A. 11·655 grs. gave $\ddot{C}$ = 28·523 and $\dot{H}$ = 6·036
B. 11·61 grs. gave $\dot{H}$ = 6·048

and of another portion similarly heated

C. 10·236 grs. gave $\ddot{C}$ = 25·204 and $\dot{H}$ = 5·258

	A.	B.	C.
Carbon . =	67·67		68·085
Hydrogen =	5·75	5·78	5·707
Oxygen . =	26·58		26·208
	100		100

And they indicate the formula $C_{40}\ H_{20}\ O_{12}$ which by calculation gives

40 Carbon . =	3057·480 =	67·84
20 Hydrogen =	249·592 =	5·54
12 Oxygen =	1200·000 =	26·62
		100

The slight excess of carbon in analysis C is no doubt an error of experiment.

This resin, therefore, belongs also to the group represented by the general expression $C_{40}\ H_{24-x}\ Oy$, and it contains more oxygen than any other resinous substance hitherto analysed.

General Remark.—In so far as we are entitled to draw general conclusions from the analyses contained in this and the preceding paper, it appears,

1. That *many* of the resins may be represented by formulæ exhibiting their elementary constitution, and the weight of their equivalents in which 40 C is a constant quantity.

2. That there appear to be groups in which the equivalents both of the carbon and the hydrogen are constant, the oxygen only varying, and others in which the hydrogen alone varies, the two other elements being constant.

In a subsequent paper I hope to extend further these first generalizations.

Durham, May 2, 1839.